

## GLIDE HEAD FOR ASPERITY DETECTION

### CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority to provisional patent application Serial No. 60/082,244, 5  
entitled "A Novel Glide Head," filed on April 16, 1998.

### BACKGROUND OF THE INVENTION

The present invention relates generally to glide heads for evaluating glide quality of a disc surface, and to related methods. More particularly, the 10  
present invention relates to a glide head with a thermal transducer for detecting defects on a disc surface.

Disc drives are used for storing information, typically as magnetically encoded data, and more recently as optically encoded data, on a disc surface. 15  
The storage and retrieval operations generally involve "flying" a read and/or write head over the surface. As storage densities increase, the fly height of the heads over the disc surfaces generally are decreased. Consequently, defect heights on the discs must decrease 20  
proportionally to reduce or eliminate contacts between the head and disc that could damage the head, the disc or both.

Glide tests are used to determine if a given disc meets the required glide quality. The glide 25  
quality of a disc is related to the disc smoothness, although other defects also may alter glide quality. In particular, tests are used by computer disc manufacturers to control and assure the quality of the disc media. Generally, all hard drive discs are tested 30  
before shipment. During a glide test, the test head or slider flies over a disc surface generally at a predetermined clearance from the disc surface, known as the glide height or fly height. The glide head or

10/21/98  
jc618 U.S. PRO

00476580-100400



slider includes a transducer that detects interactions between the disc and the glide head due to defects on the disc surface.

5 The glide heads are selectively moved under the control of electronic circuitry to any one of a plurality of circular, concentric data tracks on the disc surface by an actuator device. Each slider body includes an air bearing surface (ABS). As the disc rotates, the disc drags air beneath the ABS, which  
10 develops a lifting force that causes the glide head to lift and fly above the disc surface. Glide heads generally are designed to have a fly height that is sensitive to the linear velocity of the disc surface relative to the glide head. For example, to detect  
15 smaller defects on a disc surface, the disc velocity can be decreased to decrease the fly height of the glide head.

A transducer can be used to detect contacts between the glide head and defects. Generally,  
20 piezoelectric transducers are used to detect vibrations that result from contact between a glide head and a disc defect. Using glide heads, the process of mapping disc defects while changing the fly height of the head requires several scans at different head fly heights to  
25 map the entire range of defects. As the speed is changed, the response of the specially designed glide head also changes. For example, if the speed is reduced, the energy of the impact is reduced, thus making it more difficult to calibrate to the defect size  
30 and height.

#### SUMMARY OF THE INVENTION

In one aspect, the invention features an asperity detection slider including an air bearing surface and a thermal transducer. The thermal

2025 RELEASE UNDER E.O. 14176



transducer is generally planar and is oriented along the air-bearing surface.

In another aspect the invention features, a method of producing an asperity detection slider, the method including depositing a thermal transducer along an air bearing surface of the slider.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic, top perspective view of a glide tester incorporating an improved glide head, where a disc is shown with phantom lines such that structure below the disc is visible.

Fig. 2 is a bottom view of an embodiment of an slider with a thermal transducer located on the air bearing surface.

Fig. 3 is a bottom view of another embodiment of an slider where a thermal transducer is located on the air bearing surface away from the slider's rear edge.

Fig. 4 is a bottom view of an embodiment of an slider where a thermal transducer covers a substantial portion of a rail on the air bearing surface.

Fig. 5 is a bottom view of a slider having two different configurations of multiple thermal transducers located along a rail on the air bearing surface.

Fig. 6 is a bottom view of an slider having an alternative configuration of multiple thermal transducers located along a rail on the air bearing surface.

Fig. 7 is a schematic perspective view of an slider having both a thermal transducer and a piezoelectric transducer.

Fig. 8 is a schematic, fragmentary perspective view of a wafer with thermal transducers located on the

2025 RELEASE UNDER E.O. 14176



surface of the wafer at locations that are contoured to be an air bearing surface of the ultimate sliders.

6.0.

Fig. 9 is a schematic, perspective view of ~~an~~<sup>a</sup> slider with a thermal transducer along a rail on the air bearing surface and electrically conductive pads deposited on a rear edge prior to the addition of protective material over the pads.

47

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

By placing a thermal transducer as an defect/asperity sensor on the air bearing surface of a slider/glide head, glide testing can be performed efficiently with a high sensitivity. After a defect strikes the thermal transducer, a resistance spike is detected to provide a signature that a defect has contacted the glide head. Furthermore, thermal transducers oriented along the air bearing surface can present a large contact area on the air bearing surface. Thus, a glide test can be performed efficiently since asperities with a greater range of heights strike the thermal transducer when contacting the glide head. A plurality of thermal transducers on the air bearing surface can be used to assess the distribution of defect heights.

Glide tests performed with piezoelectric (PZT) transducers can be accomplished efficiently since defects with a wide range of heights are detected in one pass over a section of the disc. It is believed, though, that glide heads with PZT transducers may give positive readings when defects pass near the glide head even when they do not strike. Thus, PZT based glide heads may result in false positive readings for defects.

Magnetoresistive (MR) type sensors used in read/write heads can operate as thermal transducers. In contrast with defect sensors placed on the air bearing

SECRET - 0852760



surface, MR sensors in read/write heads are located on a side of the slider adjacent the air bearing surface and have only an edge of the MR sensor in contact with the air bearing surface. After contact with an defect, the heat generated by the contact changes the resistive properties of the MR sensor. As a result, the measurement of the resistance of the MR transducer biased by a constant current source is distorted by a spike and subsequent decay. Because of the narrow profile along the air bearing surface presented by the MR sensor in a read/write head, few defects will strike the glide head at the MR sensor with the MR sensor at the trailing edge side. Collisions with defects that strike such a glide head away from the MR sensor may not produce a voltage spike in the resistance measurement.

Thus, thermal defect detection methods using either MR read/write heads having a narrow MR sensor track width, or asperity detection sliders adapted from MR read/write head designs having an increased MR sensor track width have inherent limitations. Using MR read/write heads, with track widths typically less than  $2.5 \mu\text{M}$ , the time for a full surface scan is extremely time consuming. Furthermore, standard MR read/write heads of the type used in disc drive systems are designed to reduce sensitivity to thermal asperity response by having increased fly heights and/or MR transducer recessed with respect to the air bearing surface. Specially designed thermal asperity heads can reduce the surface scan time and increase the thermal asperity response by using a somewhat wider MR sensor track, for example,  $60 \mu\text{M}$ . This wider MR sensor track still only covers a very small portion of the slider air bearing surface.



CC

10

Using this alternative slider production procedure, thermal transducers can be placed on the air-bearing surface at the wafer level prior to cutting the individual sliders. Thermal transducer application on the air bearing surface provides for the performance of many processing steps at the wafer level. In particular, the placement of the thermal transducer on



**THE UNIVERSITY OF CHICAGO**

5  
10  
15  
20  
25  
30

The air bearing surface of the slider generally includes contoured portions such as rails for aerodynamic performance. The thermal transducers generally are placed on an extended portion of the surface such that they will provide the point of contact with an asperity. A single large transducer can provide for defect detection over a larger range of defect heights. The use of multiple thermal transducers can provide for grading of asperities, as described further below. Thus, selection of the number and placement of the thermal transducers involves a balance between the processing complexity and the amount of information desired about the nature of the asperities. In preferred embodiment, the one or more thermal transducers cover an area of the air bearing surface from about 0.05 mm<sup>2</sup> to about 5.0 mm<sup>2</sup>.



5  
10

15

20

25

30

4/2/2



Sub 22 Arnold

electrical contact between thermal transducer 156 and the top of glide head 132. Pads 160, 162 are connected to a measurement circuit at the top of the glide head such that the electrical resistance of thermal transducer 156 can be monitored. To improve the aerodynamic performance, steps 164, 166 are located near front edge 168 of glide head 132. The contoured features on the air bearing surface can be varied to achieve a desired aerodynamic performance of the glide head.

SECRET

Thermal transducer 156 generally is made from material with an electrical resistance that varies with temperature. For example, materials such as NiFe alloy used to form magnetoresistive transducers also exhibit a thermal resistance effect. Preferred materials for producing the thermal transducers have a resistance that is relatively insensitive to magnetic fields since the defect measurement should not be sensitive to the magnetic field near the glide head. Preferred materials for forming the thermal transducer include, for example, nickel (Ni). Electrically conductive pads 160, 162 generally are made of conducting metal, alloy or metal compound. Electrically conductive pads 160, 162 are made preferably from gold.

Sub 23

The back edge of glide head 132 generally flies closer to the surface of the disc than the front edge. The pitch of glide head 132 is due to aerodynamic forces. Therefore, placement of the thermal transducer near the rear edge of the glide head provides for the detection of smaller asperities for a given fly height. Nevertheless, if desired the thermal transducer can be placed away from the rear edge. Such an alternative embodiment is depicted in Fig. 3. Thermal transducer 180 is located on rail 182. Electrical conduction



strips 184, 186 provide for electrical conduction between thermal transducer 180 and electrical conduction pads 188, 190. Electrical conduction pads 188, 190 provide a path of electrical conduction between strips 184, 186 and the top of glide head 132. Electrical conduction strips 184, 186 can be produced from electrically conductive metal, alloys, metal compounds or combinations thereof.

If the thermal transducers covers a substantial portion of the length of the glide head, defects with a wide range of heights strike the thermal transducers to produce a spike in the resistance of the transducer rather than striking a portion of the air bearing surface away from a transducer. Thus, another alternative embodiment of a glide head 132 is shown in Fig. 4. Thermal transducer 200 covers substantially all of rail 202 up to step 204. Thermal transducer 200 is in electrical contact with electrically conductive pads 206, 208.

A plurality of thermal transducers can be used on a single glide head. In preferred embodiments, a plurality of thermal transducers cover a substantial portion of the length of the glide head. In particular, the plurality of transducers can cover a substantial portion of a rail or other contour on the air bearing surface. The use of a suitably placed plurality of thermal transducers provide for the grading of defects by height. In other words, defects with different ranges of heights strike the glide head at different portions of the air bearing surface due to the pitch of the slide during use. Identification of the transducer that is struck indicates that the asperity has a height within a particular range.

Sub  
F3  
cancel

G.V.

SECRET



Two embodiments for the placement of multiple transducers are indicated in Fig. 5. In the slider 132 of Fig. 5, rail 250 has one configuration of multiple transducers while rail 252 has a second configuration.

5 The placement of thermal transducers on more than one rail or other contour provides for the simultaneous detection of asperities on two portions of the disc surface. The motion of the slider across the disc surface can be adjusted accordingly.

10 Thermal transducers 254, 256, 258 are located on rail 250. Pad 260 and strip 262 provide electrical contact to a common ground for transducers 254, 256, 258. The use of a common ground reduces the space needed for electrical conduction strips and reduces  
15 processing related to the deposition of conduction strips. Pads 264, 266, 268 and strips 270, 272, 274 provide electrical conduction to transducers 254, 256, 258, respectively, for resistance measurements.

Thermal transducers 290, 292 are located on  
20 rail 252. Pads 294, 296 and conduction strips 298, 300 provide electrical connections to transducer 290. Similarly, pads 302, 304 and conduction strips 306, 308 provide electrical connections to transducer 292. In contrast with transducers 254, 256, 258, transducers  
25 290, 292 do not share a common ground.

An alternative configuration of slider 132 having multiple thermal transducers is depicted in Fig. 6. Thermal transducers 320, 322, 324, 326 are located on rail 328. Transducers 320, 322, 324, 326 share a  
30 common electrical ground provided by pad 330 and conductive strip 332. Pads 340, 342, 344, 346 provide the remaining electrical connections for transducers 320, 322, 324, 326, respectively, with the top of slider 132.

2025 RELEASE UNDER E.O. 14176



A slider with a thermal transducer on the air bearing surface can also have one or more additional transducers for the detection of defects. The use of multiple types of transducers provides for a comparison between measurements made with different types and/or configurations of transducers. For example, thermal transducers which are particularly sensitive to actual strikes with an asperity can be used to evaluate whether piezoelectric transducers produce false positive signals from near misses with asperities.

Moreover, multiple types of transducers for  
25 detecting defects can be used to provide more accurate  
defect detection. For example, the measurements from  
multiple types of transducers can be compared with a  
matrix of threshold values to evaluate whether a defect  
has been struck. In other words, if one transducer  
30 produces a particular reading, a corresponding threshold  
value can be used for the other transducer to evaluate  
whether or not a defect was struck. A correlation of  
the measurements from the multiple transducers should  
reduce the number of false positive readings and false



negative readings. Thus, measurements can be made with a greater confidence level.

Sub G2  
SECRET  
5 An embodiment of glide head 132 with different types of defect detecting transducers is depicted in Fig. 7. Glide head 132 includes rails 400, 402 along air bearing surface 404. Thermal transducer 406 is located on rail 402. Electrically conductive pads 408, 410 provide electrical conduction between transducer 406 and the top surface 412 of glide head 132. Pads 408, 10 410 are connected to resistance measurement circuit 414 for the evaluation of changes in resistance of transducer 406. Pads 408, 410 are located along or near rear edge 416 of glide head 132. Piezoelectric transducer 420 is located on wing 422 along top surface 15 412. Piezoelectric transducer 420 is connected to measurement circuit 424.

SECRET  
20 Regardless of the particular embodiment for the placement and number of the thermal transducers on the air bearing surface, the thermal transducers generally are formed on the air bearing surface following the contouring of the air bearing surface to form the gross shape of the air bearing surface. The thermal transducers can be deposited using any of the vacuum metal deposition techniques, such as sputtering. 25 Conduction strips and conduction pads can be similarly deposited. Generally, the components are covered with a protective, electrically insulating layer such as diamond like carbon.

Sub G3  
Wing  
30 The order of processing depends on the approach used to produce the slider from a wafer. In conventional approaches, the air bearing surface is formed from a cut edge of the wafer. In these approaches, the electrically conductive pads can be deposited on the surface of the wafer prior to the



Sub 93201d  
slicing of the wafer. The pads are positioned on the wafer surface such that they are along the rear edge of the slider after the sliders are cut from the wafer.

Following the cutting of the individual  
5 sliders, the air bearing surface generally is subjected to one or more stages of lapping (e.g., rough lap, smooth lap and crown lap) to smooth the surface. Lapping generally involves mechanical, chemical and/or mechanical/chemical polishing. Following a desired  
10 amount of lapping, the air bearing surface is contoured using thin layer deposition techniques, milling techniques such as ion milling, reactive ion milling or laser ablation, or a combination thereof. Following  
15 contouring, the thermal transducers and conductive strips are applied to the air bearing surface. A protective coating then can be applied, if desired.

As noted above, a preferred approach for the production of sliders with thermal transducers on the air bearing surface involve the cutting of sliders from  
20 wafers such that the air bearing surface of the sliders is formed from a surface of the wafer. Thus, a greater portion of the slider preparation is performed at the wafer level. In particular, the contouring of the air bearing surface and the placement of the thermal  
25 transducers can be performed on the wafer prior to slicing the individual sliders. A portion of a wafer processed to produce sliders configured as shown in Fig. 2 is depicted in Fig. 8.

To form the sliders with the thermal  
30 transducers located on the air bearing surface, a plurality of thermal transducers 500 can be applied along the smooth surface 502 of wafer 504, as shown in Fig. 8. Thermal transducers 500 are located on rails 506 contoured onto surface 502. Representative rails



506 are noted in Fig. 8. Additional transducers such as a piezoelectric transducer also can be placed on the opposite surface of the wafer prior to the slicing into individual sliders.

5 After completing the desired processing of the wafer surfaces, the wafer is "diced" or sliced along cutting alleys 508, as indicated in Fig. 8, to produce cut faces. A first cut produces a set of rows with each row containing a plurality of sliders. A second cut  
10 along each row produces the individual sliders with four cut faces. A small quantity of material is lost along cutting alleys 508 during the slicing process.

Following slicing, any desired lapping of the cut edge is performed. In this processing approach, the  
15 electrically conductive pads 510, 512 of the slider are applied along the rear edge on the smoothed cut surface, as shown in Fig. 9. Additional details of the processing of sliders to produce an air bearing surface from a wafer surface is described in commonly assigned  
20 and simultaneously filed patent application, 09/176,352 to Sundaram et al., entitled "GLIDE HEADS AND METHODS FOR MAKING GLIDE HEADS," incorporated herein by reference.

In order for asperity detection systems to be  
25 useful to test discs with different tolerances, glide heads generally are designed to have fly heights that depend on the linear velocity of the slider relative to the disc surface. The fly height is selected such that asperities larger than a tolerance value strike the  
30 glide head and preferably strike the thermal transducer. The linear velocity is set accordingly.

Tolerance levels for asperity detection are generally set lower than tolerances established for disc flatness in actual operation since fly heights during

SECRET 000000

Sub  
Ed  
Conrad



actual operation can be altered by additional factors including, for example, flutter of the spinning disc, spindle misalignment, high altitudes and temperature fluctuations. The glide head is swept across the disc surface at a suitable speed such that the relevant portions of the disc surface are examined with the glide head. The rotation rate generally is varied as the asperity detection slider is moved to different radial positions along the disc to maintain the relative linear velocity approximately constant.

The embodiments described above are intended to be illustrative and not limiting. Additional embodiments are within the claims below. Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

2025-03-27-00